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THE METAMERISM OF NEPHELIS.

A CONTRIBUTION TO THE MORPHOLOGY OF THE NERVOUS SYSTEM, TOGETHER WITH A DESCRIPTION OF *NEPHELIS LATERALIS.*

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NEPHELIS differs from most of the leeches in the absence of well-marked sense organs on the first ring of each metamere, and hence the means usually efficient for determining metamерism in other leeches is wanting. Professor Whitman had already worked out the distribution of the nerves in Clepsine and found a complete agreement between this and the sensillae (sense organs). It was proposed to apply the same method to Nephelis, therefore, in which form the sensillae were not so apparent.

A large number of individuals were collected from widely different localities, from Wood's Holl, Mass., to Wolf Lake, near Chicago. Color markings proved useless as criteria for determining species, and the method of counting the rings and noting the variations of size was used. A careful study of all the individuals resulted in placing all the forms in one species, — *Nephelis lateralis*. This name was chosen because of its priority. The generic name *Nephelis* was retained also for its priority, though Dr. Blanchard, in France, has brought the name *Erpobdella* into his descriptions.

DESCRIPTION. The size of the adult varies from 4 cm. to 10 cm. at rest. Anterior to the sexual organs the body tapers slightly to the mouth; posterior to them it continues about the same size until just in front of the anus, whence it tapers to the sucker. A transection of the body is lenticular, though in the clitellar region it approximates a circle. The body flattens in swimming, as in *Hirudo* and *Macrobdella*. The color varies from a light chocolate brown free from pigment to almost a coal black free from any light areas. The total number of annuli is 106 to the acetabulum. The oral

sucker is not prominent, and the anal sucker is small. The male orifice lies normally between annuli 36 and 37. The female orifice lies normally between annuli 38 and 39.

The first pair of nephridiopores lies between annuli 16 and 17, at the posterior edge of the seventh (VII) metamere. There are four pairs of nephridia anterior to the male orifice, while posterior to them are 13 pairs of pores, the last pair lying between annuli 96 and 97. The nephridiopores are separated by five annuli. The anus is dorsal and lies behind the 104th annulus. The clitellum consists of 15 annuli — from 28 to 42 inclusive. It includes the last four rings of metamere X and the first of metamere XII.

The whole number of metameres is 34. In the body region they consist of five annuli each, as is shown externally by the nephridiopores. In the terminal regions these are more or less reduced and the limits were determined by the innervation as follows :

I consists of the prostomium ; II of annuli 2 and 3 ; III of a single ring, 4; IV of a single ring, 5; V of 6, 7, 8; VI of 9, 10, 11. Metameres VII to XXIV, inclusive, are normal, composed of five rings each. XXV consists of annuli 102, 103, and the anterior half of 104 ; XXVI, of the posterior half of 104 and 105. XXVII consists of 106, the last annulus and the acetabulum, the top part of the sucker. XXVIII to XXXIV consist of the sucker disc.

The number of eyes is six ; and they are arranged in pairs: the first pair lies in the second annulus and looks forward ; the second pair lies wholly in the fourth and looks outward and backward; the third pair lies partly in the fourth and partly in the fifth and looks outward and backward.

Habitat. Nephelis is found in fresh-water brooks and ponds wherever food is plentiful. They are not parasitic, but feed on the débris of animals as does Aulastoma. They are usually found partly buried in mud or sand or on the under side of submerged objects.

Nervous System. The nervous system consists of three well-marked divisions: the central, the sympathetic, and the intermuscular systems.

The *central system* lies in the ventral blood sinus underneath the alimentary canal. It consists of a "brain," or supraoesophageal part, together with a fused mass of ganglia, the suboesophageal ganglia, a chain of 18 ganglia (neuromeres), and a fused mass of ganglia, the anal ganglia. The neuromeres are joined together by paired connectives, and between the connectives lies a small bundle of nerve fibers known as the median nerve, or Faivre's nerve. Within each pair of connectives lie two "colossal" cells.

The general shape of a body neuromere is a flattened ellipsoid with a slight axial groove. The bodies of the neurons lie in six capsules, arranged about the body of the ganglion in pairs as follows: one pair on the ventral side and one pair on each lateral face. Within the ganglion are two "colossal" cells similar to those in the connectives. Two pairs of nerves arise from the ganglion and divide so as to innervate the somite, as will be described. The anterior pair arises from two roots which quickly fuse, and hence this pair is the homologue of the first two pairs of the three pairs of nerves in Clepsine. Just outside of the ganglion, between the two pairs of nerves, lie two "colossal" cells, one on each side, the prolongations of which fuse into the nerve trunks. These have been called "Leydig's cells."

Every factor that enters into a body neuromere is found in every neuromere in the central system.

The anterior nerve innervates the fourth and fifth annuli of the preceding metamere and part of the first annulus of its own metamere. The posterior nerve innervates the few dorsal sensillae of the preceding fourth and fifth annuli, the principal dorsal sensillae of the first annulus, and the lesser dorsal sensillae in the second and third annuli. Comparison with Whitman's description of Clepsine shows this distribution to be identical with that found by him.

Applying the above plan to the terminal fused parts of the nerve chain, — the "brain" and suboesophageal ganglia in the head region and the anal ganglia in the posterior end of the body, — we have been able to analyse them completely.

The anal ganglia comprise ten neuromeres; the three anterior neuromeres differing but slightly from normal body neuromeres, while the succeeding seven are modified by condensation. These latter represent the seven neuromeres in the anal ganglia of *Clepsine*, while the former mark the extent to which fusion has gone on in *Nephelis* beyond that in *Clepsine*. In the former the nerves emerge in two pairs with the "Leydig's cells" between them; in the latter they emerge fused into a single trunk with the "Leydig's cell" lying alongside. The distribution shows the limits of the metameres as given above.

In the anterior end of the nerve chain, the "brain" and suboesophageal ganglia, though much more modified, yield to the plan of the body neuromere, and again the distribution readily defines the limits of the metameres. The suboesophageal ganglia consist of five neuromeres. II lies on the side of the collar, while III to VI are closely fused together, yet each neuromere of this region contains every factor that goes to make up a body neuromere.

The nerves of the last neuromere, VI, emerge as in a body neuromere, the others as single trunks. In neuromere VI the "Leydig's cell" lies between the nerves; in V it lies in the angle of the first branching; in the others it lies alongside the trunks.

The "brain" or neuromere I lies above the oesophagus. In it, as in the other neuromeres, is found every unit that is found in a body neuromere. The "brain," therefore, does not differ morphologically from any other neuromere. The distribution in this fused region shows on analysis the same morphological arrangement as in the body metamer, and the division of this region into metameres as given above was derived from this source.

The Intermuscular Nerve Ring. In the second and fifth annuli of each body metamer, between the layers of the longitudinal muscles and the circular muscles, are found two rings of nerve cells and fibers. Each ring receives fibers from the central system and from sensillae on the surface, and gives rise to fibers that go to the central system and to the muscles. At definite and constant points about the ring are ten groups of

bipolar cells, and these cells resemble the "Leydig's cells" above mentioned and the "colossal" cells of the connectives. These intermuscular nerve rings are joined longitudinally by ten lines of bipolar cells, a single cell in each line joining two consecutive groups of bipolar cells. The cell body of these cells lies about midway between any two rings. These connective bipolar cells are also strictly comparable to the "Leydig's cells." This system is complete in that a ring may receive stimuli, send forth motor stimuli, and send impulses to other parts of the same system. In its application to the origin of a metamere composed of five annuli it confirms Whitman's proposition that the five-ringed metamere arose from the three-ringed metamere by the doubling of the second and third Clepsine rings. The third annulus in Nephelis is the posterior half of (Clepsine) two, and four in Nephelis is the anterior half of (Clepsine) three.

The Sympathetic System. This is well developed over the wall of the entire alimentary tract. It is connected with the central system at the collar. It passes off from the collar in three pairs of branches, a dorsal, a lateral, and a ventral, which soon fuse and form an intricate meshwork with the fibers from the many multipolar cells on the muscular wall. There is some evidence that the sympathetic system persists in the post-anal region as a remnant of the system that functioned when the anus was terminal.

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